THE INDIVIDUALITY OF PUBLIC UTILITIES, NOTABLY WATER WORKS

By W. E. Miller

The fact that there has been a popular tendency in the past to measure the reasonableness of rates of one public utility plant, or even to fix rates for a new plant, by a comparison of those in force in other cities seems to warrant a little consideration of the differences between various plants of like kind and between the conditions under which they are constructed and operated. These differences seem generally far from being fully appreciated except by the comparatively few who have had something to do with a considerable number of such properties and had occasion to make comparison between them.

The popular comparison of rates of different water or other utility plants appears to be merely a superficial one, due to the lack of knowledge and appreciation of the great differences that may exist even in cities of similar size.

Certain water works franchises have specified that the rates to be charged by the grantees under those franchises should not exceed the average of those in certain other cities named therein.

Those who have had experience in construction and valuation of railroad property, and doubtless others as well, are aware of the existence of a wide range of values per mile of roadbed or track, which are the common bases of comparison of different roads. The heavier types of construction on heavy traffic roads is by no means the only cause of the differences in costs or values per mile. Construction difficulties may be relatively so serious in the case of a so-called small road, or light traffic road, as to offset the extra expenses for stiffer construction in the cases of certain higher class lines. These relative construction difficulties may, in other cases, operate to augment, instead of to offset, the differences in cost that are due merely to construction standards. Topography and geology of the country traversed are important factors in the results.

In the field of waterworks construction there are many different factors and combinations of them which enter into the costs of plants. The mere costs of prospecting for and developing water supplies for relatively small communities have often been relatively, if not actually greater than in the cases of much larger cities, particularly so when the losses involved in necessary changes from one source to another, if not to a third and even a fourth source, are considered.

Topography and geology are factors as influential in the costs of water plants as they are in railroads. Even climate is an important consideration since it affects the depths at which mains and services are to be laid and the character of other features. One does not have to travel very far in certain sections to find standard trench depths differing quite remarkably. For example, at Chippewa Falls, in the west central part of Wisconsin, the franchise granted to the water company required a depth of 9 feet of cover, which involved cutting into a considerable amount of solid rock. At Hurley, on the north line of Wisconsin, and Ironwood, in upper Michigan, the water mains are laid in a trench only 5 feet deep and it is understood that very little, if any trouble through freezing of mains has occurred. Heavy snow covering throughout the winter is given as the reason for the comparatively shallow penetration of frost in those places.

Milwaukee's specifications for pipe laying call for a depth of 6½ feet to the center of pipe.

Within the state of Wisconsin alone the standard depths of cover on water mains in different cities have been found to range from 4½ feet to 9 feet.

It seems needless to say that the character of material to be excavated and the cost of excavating it have also varied between wide limits, covering everything from a merely damp loamy sand, requiring no use of picks, sheet piling or pumps, to solid rock, involving drilling and blasting, or to wet sand and gravel requiring tight sheathing and much pumping.

Conditions very favorable to low cost of pipe laying predominate in some cities while in others the work is very difficult almost throughout. One small city in Wisconsin within the writer's knowledge has found it impracticable to finance the construction of a water works solely because of the fact that the pipe laying would involve the expense of almost continuous excavation of solid rock.

In discussing the distribution system, which forms so large a part of the cost of every water works plant, it is also of interest to note how various plants differ as to average size of pipe in mains. This, as well as the cost of laying, materially affects the total investment. Some water pipe systems contain a considerable proportion of small wrought iron and steel pipe, ranging from $\frac{3}{4}$ inch to 3 inch running longitudinally with the streets and classed as mains, although serving only private consumers, while other cities have nothing smaller than 4 inch or even 6 inch pipe.

Below is a tabulation for a number of Wisconsin water plants, showing for each case the population by 1910 census, the total mileage of mains and the average pipe diameter. The average size was determined by multiplying each diameter by the length of that size and dividing the sum of those products by the total length of all sizes.

TABLE I

Class A Plants

PLACE	POPULATION	MILES OF MAINS	AVERAGE DIAMETER INCHES
Private Ownership			
Ashland..........	11,594	30.70	6.87
Beloit............	15,125	27.55	6.38
Chippewa Falls...	8,893		
Green Bay........	25,236	96.74	4.13 (Lowest)
Janesville.........	13,894	32.55	5.60
Marinette........	14,610	33.66	5.22
Merrill...........	8,689	19.92	5.49
Oshkosh..........	33,062	60.34	6.23
Racine...........	38,002	76.43	7.06
Superior..........	40,384	61.82	7.95 (Highest)
Municipal			
Appleton.........	16,773		
	All sizes	29.72	
	C. I. only	22.62	5.57
Eau Claire........	Pipe data not	available	6.79
Fond du Lac.....	18,797	33.62	5.81
Kenosha..........	21,371	41.93	6.12
La Crosse.........	30,417	63.97	8.22
Madison..........	25,531	51.13	5.18 (Lowest)
Manitowoc.......	13,027	24.63	6.94
Milwaukee........	373,857	499.00	8.61 (Highest)
Sheboygan........	26,398	68.50	5.69
Watertown.......	8,829	20.59	6.46
Waukesha........	8,740	25.86	6.70
Wausau..........	16,560	31.92	5.33

Class B Plants

Private			
Antigo............	7,196	13.97	5.46
Beaver Dam.....	6,758	16.67	6.17
Mellen...........	1,833	3.68	6.30
Menomonie.......	5,036	10.91	5.65
Oconto...........	5,629	14.48	5.28 (Lowest)
Ripon............	3,739	11.63	5.92
Stevens Point....	8,692	16.04	6.09
Washburn........	3,830		
	All sizes	8.43	5.50
	4" and larger	6.67	5.55

TABLE I—Continued

Class B Plants—Continued

PLACE	POPULATION	MILES OF MAINS	AVERAGE DIAMETER INCHES
Private			
Whitewater	3,224	8.76	6.83 (Highest)
Municipal			
Baraboo	6,324	14.36	6.20
Berlin	4,636	9.58	6.57
Columbus	2,523	6.86	5.51
Edgerton	2,513	6.52	5.69
Fort Atkinson	3,877		
	4″ and larger	8.78	5.20
	All sizes	10.38	4.90
Grand Rapids	6,521	16.65	5.26
Hudson	2,810	8.78	4.69
Kaukauna	4,717	10.46	6.88
Lake Geneva	3,079	7.72	5.89
Lancaster	2,329	8.59	4.44
Marshfield	5,783	8.99	7.72
Menasha	6,081	13.29	7.87
Monroe	4,410	8.98	5.39
Neenah	5,734	13.75	6.53
New Richmond	1,988	3.22	5.63
New London	3,383	5.87	5.70
Platteville	4,452	14.65	4.75
Portage	5,440	18.37	4.24 (Lowest)
Port Washington	3,792	7.17	6.40
Rhinelander	5,637	15.28	5.92
Rice Lake	3,968	9.76	4.73
Richland Center	2,652	7.68	5.05
River Falls	1,991	5.16	5.65
Shawano	2,923	5.94	5.36
South Milwaukee	6,092	7.72	6.17
Sparta	3,973	12.95	4.93
Stoughton	4,761	13.37	4.43
Sturgeon Bay	4,262	1.84	9.43 (Highest)
Tomah	3,419	7.63	4.74
Tomahawk	2,907	5.31	5.49
Two Rivers	4,850	10.05	4.61
Waupaca	2,789	9.71	5.27
West Allis	6,645	27.90	6.55
Oconomowoc	3,054	8.74	6.88
Plymouth	3,094	9.83	4.89

In addition to the foregoing, the following similar statistics for certain water plants outside of Wisconsin are available:

PLACE	POPULATION	MILES OF PIPE	AVERAGE DIAMETER INCHES
Chicago, Ill......	2,185,283 (1910)	2,362.00 (1911)	8.62
Indianapolis, Ind.	233,650 (1910)	364.10 (1914)	8.28
Charleston, W.Va.	32,000 (Est. 1914)	52.37 (Jan. 1, 1914)	4.46
Pennsylvania Water Co., Wilkinsburg, Pa...		146.90 (1910)	8.78

The foregoing figures were, in most cases, compiled from statistics furnished by the plants for the year ending June 30, 1913. In a few instances statistics on pipe mileage for that year were not available and those of somewhat earlier dates were used, being taken from inventories and valuations.

In those cases where much pipe smaller than 4 inch is used it is evident that the fire service is either not coëxtensive with the pipe system or it is of a lower order of excellence than in those cases where no such small pipe is found.

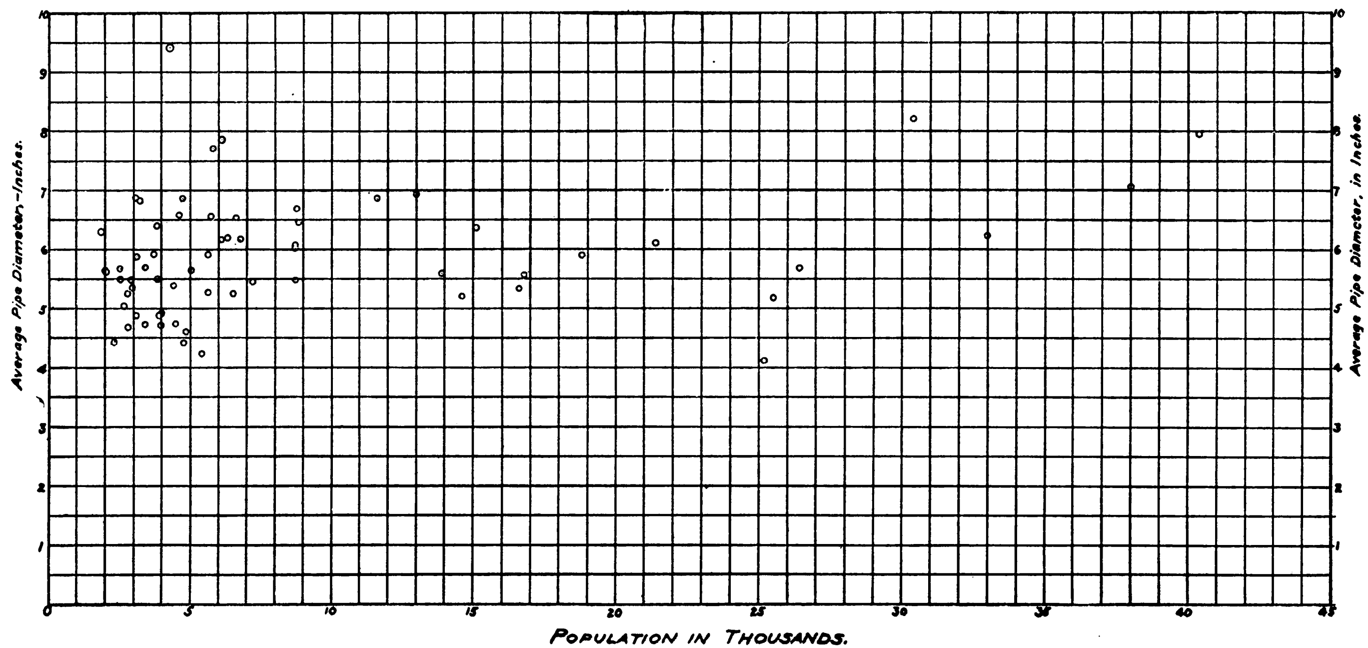
The question sometimes arises as to how marked is the tendency for the average diameter of distribution mains of a water plant to increase with the total mileage or with the population of the cities supplies. In order to most clearly show that tendency so far as the foregoing figures indicate its existence those values have been put in graphical form as shown by the diagrams (fig. 1) and (fig. 2). The former shows the various cities arranged in the order of magnitude of their population, the second in the order of total pipe mileage.

The great diversity of average pipe diameters can hardly be fully accounted for by differences in local conditions alone but are doubtless due in large measure to differences in personal ideas of those who have had to do with the development of these systems. It is also to be remembered that these several plants will certainly not show the same degree of adequacy under their respective sets of operating conditions and requirements. They are all, doubtless, fully adequate for the ordinary daily commercial service, but the capacity for good direct pressure fire service in addition is low in

FIG. 1

Showing Variation in Average Diameters of Water Mains in 64 Wisconsin Cities

Cities arranged in order of population



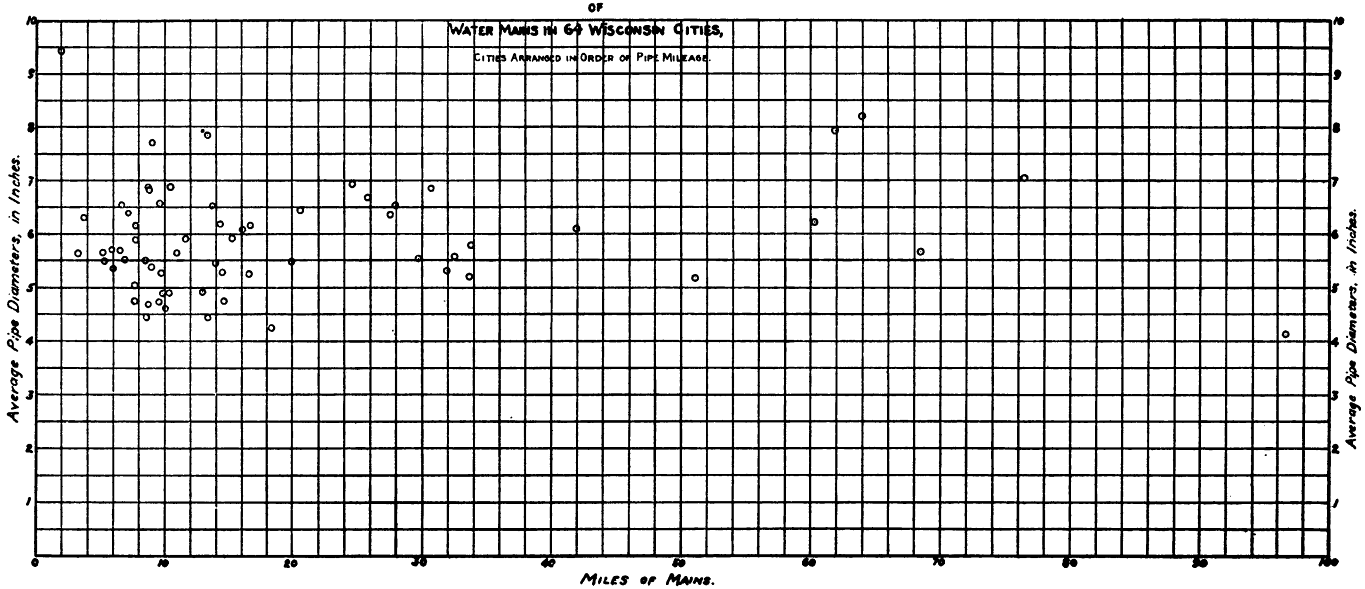


FIG. 2

SHOWING VARIATION IN AVERAGE DIAMETERS
OF
WATER MAINS IN 64 WISCONSIN CITIES,

CITIES ARRANGED IN ORDER OF PIPE MILEAGE.

those cities where average pipe diameters are small. In two cities of similar size and having very similar pipe systems the fire service will be poorer in that one using the greater amount of water in the general commercial service.

It can scarcely be contended that the diagrams (figs. 1 and 2) establish the existence of a tendency for the average diameter of mains in a system to increase as the mileage increases or as the city grows in population. The developments of single or individual systems would be much more reliable indications of the natural changes in average pipe sizes, as the great diversity of ideas of those in charge of extensions of various systems and the great diversity of other local conditions would largely be eliminated.

Figure 3 shows the change in average pipe diameter with increase in total mileage in two water pipe systems in Wisconsin, those of Madison and Milwaukee.

In order to indicate the approximate effect of difference in average pipe diameter upon the average cost per foot of all mains in a system, the diagram (fig. 4) has been prepared from unit prices used in 1911 valuation of the Milwaukee Water Works. That valuation was made by the engineering staff of the railroad commission of Wisconsin for the commission's use in determining equitable rates. The diagram shows values per foot of mains including material and labor costs. These unit values are, of course, not applicable in valuation of other pipe systems where conditions are different. The diagram merely indicates approximate relative unit values on different sizes, or average sizes, under certain specific conditions.

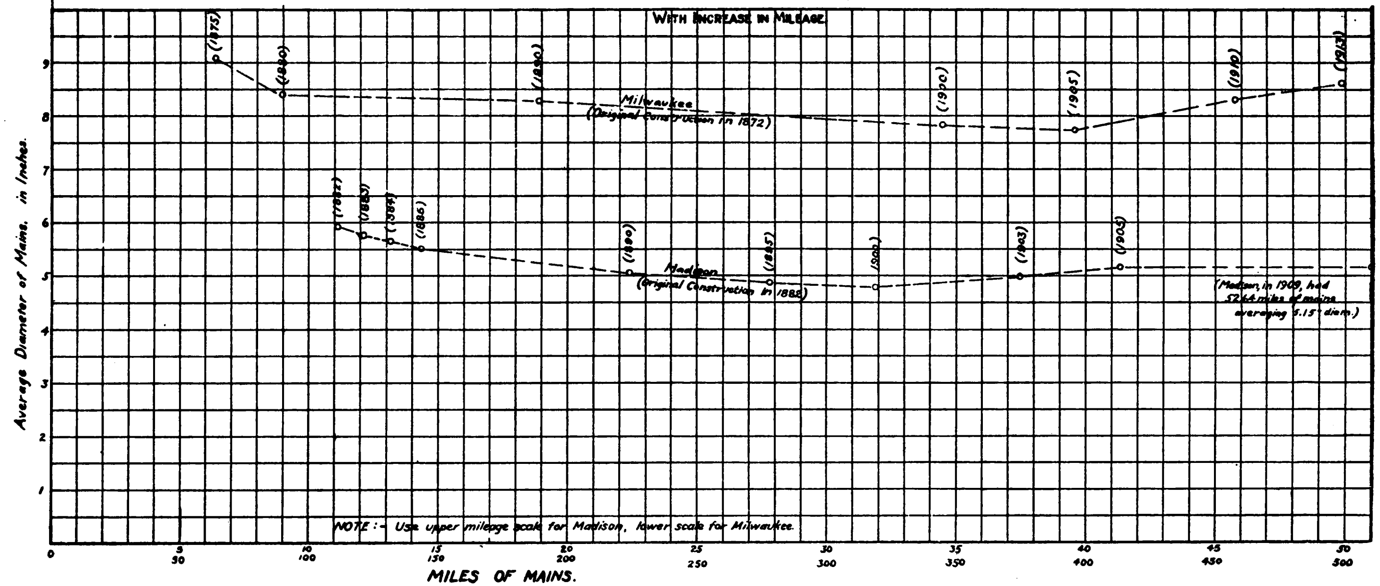
Were all conditions except average pipe diameter similar in Madison and Milwaukee, figures 3 and 4 would indicate that the cost of the Milwaukee system per mile or per foot would exceed that of Madison by about 60 per cent.

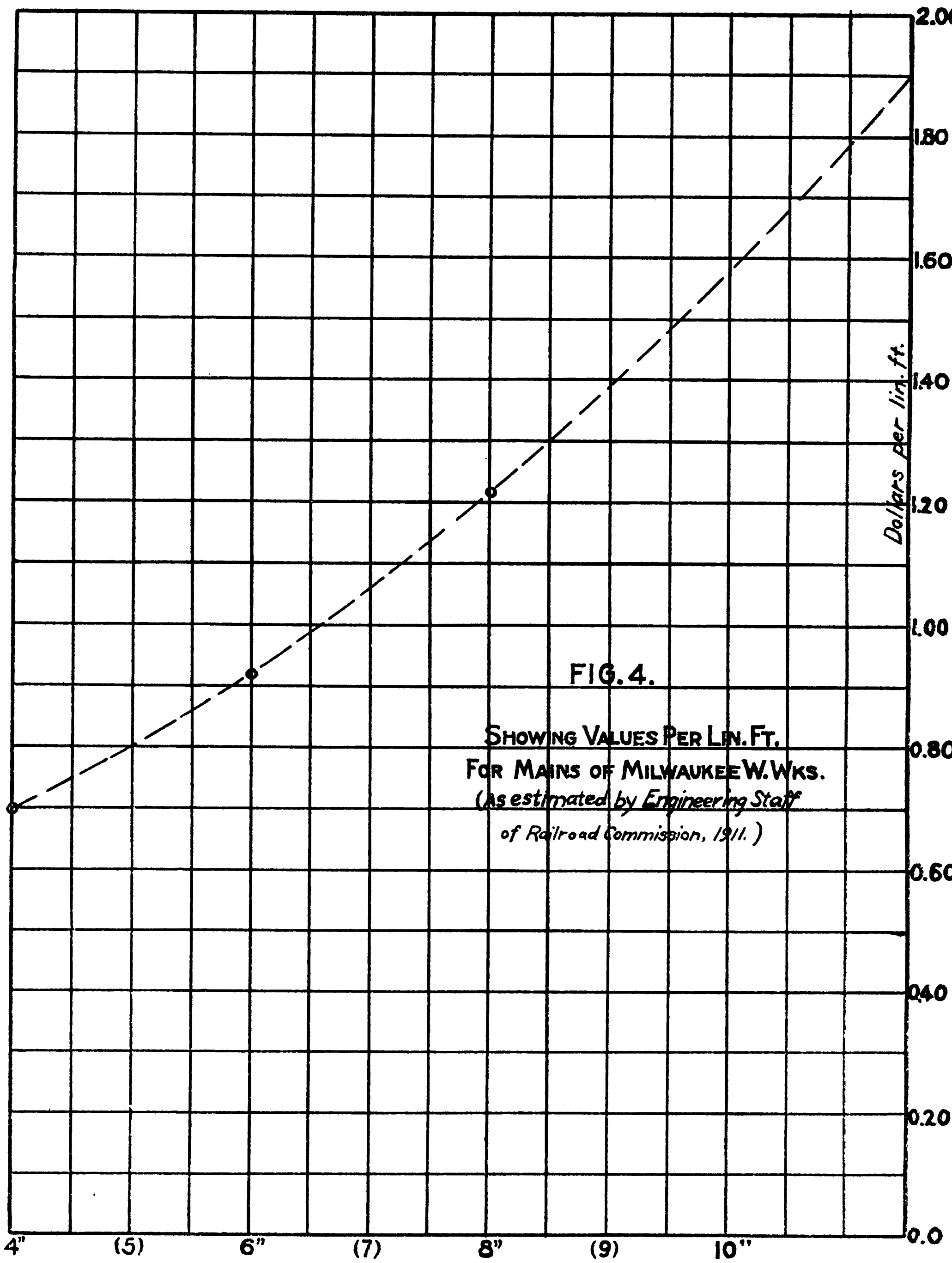
Among the numerous factors entering into the problem of the pipe system and into the differences existing between the several systems named above, both as to average diameter and cost per foot or other unit of length, are:

1. Depth of cover required to prevent freezing.
2. Character of soil as regards difficulty of excavating it.
3. Rates of cost for materials and labor.
4. Average and maximum present rates of demand of private service.

FIG. 3.

SHOWING CHANGES IN AVERAGE DIAMETERS OF WATER MAINS IN MILWAUKEE & MADISON, WIS. WITH INCREASE IN MILEAGE.





PIPE DIAMETER

5. Provision or lack of provision of a temporary surplus of capacity to take care of future extensions into new territory.

6. Provision for increased demand in existing territory.

7. Provision for reduced carrying capacity by incrustation or tuberculation.

8. Character of fire service to be provided.

9. Location of pumping plant with respect to center of distribution.

10. Permissible total loss of head by friction (affected by topography of territory) etc.

A little reflection on the number of factors that affect the design, development and cost of a water pipe system, and on the range of values any one factor may have in different cases shows that it is but natural for such systems to possess decided individuality.

The entire distribution system of a public water works property often represents two-thirds or even a greater proportion of the total plant value, yet in a number of cases it falls to materially less than one-half the total. Such differences are, in part, due to lack of uniformity in the matter of ownership of service pipes and meters, these being generally counted as parts of the distribution system in cases where they are installed by and at the expense of the water works, instead of by property owners or tenants, as is the custom in some cities.

While the foregoing and other facts show that very little is to be gained by merely comparing total water plant investments or valuations in different cases on any basis, it is considered of some interest to note how such total values do vary.

Thirty-three of the Wisconsin water works plants of which physical valuations have been made by the engineering staff of the railroad commission of Wisconsin for the commission's use and consideration in rate or purchase cases compare as follows on the "per capita" basis:

2	Plants showed values between	$14.70	and	$15.00
14	Plants showed values between	15.00	and	20.00
10	Plants showed values between	20.00	and	25.00
4	Plants showed values between	25.00	and	30.00
2	Plants showed values between	30.00	and	35.00
0	Plants showed values between	35.00	and	40.00
1	Plant showed a maximum of	40.96		
33	Plants showed an average of	$21.34		

The same plants compared on the basis of total physical valuation per service connection show the following relative amounts:

2 Plants had values between $75.00 and	$100.00
12 Plants had values between 100.00 and	150.00
10 Plants had values between 150.00 and	200.00
5 Plants had values between 200.00 and	250.00
4 Plants had values between 250.00 and	300.00
33 Plants averaged	$171.91
22 Plants in the largest groups averaged	$146.95

When compared on the investment per million gallons pumped during a year these plants appeared as follows:

5 Plants furnished no pumping statistics	
3 Plants had values between $380 and	$400
4 Plants had values between 400 and	500
9 Plants had values between 600 and	703
5 Plants had values between 800 and	1000
6 Plants had values between 1000 and	1300
1 Plant had maximum value of $6028	

On this basis of comparison it is seen that the capital charges for each million gallons of water pumped, if computed at the same rate for all, were almost sixteen times as much in the highest case as in the lowest.

The valuations to which reference has been made herein were not the final and official valuations fixed by the commission on the utilities as going concerns but included merely the physical property. The fact that the difference between the two is often quite considerable appears to be far from being generally realized.

Not only do public utilities vary widely as to comparative costs or values but they serve communities having decided peculiarities and individualities of their own. Great differences are found in the average wealth of the inhabitants of various cities, in the extent and character of the industries located therein, in the topography and geology of the land on which they are built and in other aspects. All these decisively affect the demands on the utilities and therefore their operating expenses, and necessary rates.

A comparison of the pumping expenses alone of 17 of the larger Wisconsin water plants, excluding Milwaukee, showed a range of from $10.38 to $32.32 per million gallons during the year ending June 30, 1913. The head pumped against, not including suction

lift, varied from 100 feet to about 230 feet. There was apparently but little relation between the pumping pressure and the cost per million gallons pumped. Some of the plants in Wisconsin pump against a domestic pressure of as low as 70 foot head while just across the state line is one (in Duluth) which raises water (in three lifts) from Lake Superior to an elevation of about 900 feet.

The extra expenses of pumping the same water twice, once from deep wells to a low reservoir or from a lake or stream to a purification plant, then to the city mains and the expenses of purification are material elements in the total cost of service of some plants and are not present in that of others.

Some plants are found to be furnishing service to substantially all, and others to less than half of the inhabitants of their respective communities. Even if all cities were built equally compact, this variation in proportions of population served would materially affect the number of consumers per mile of mains, or in other words, the number of feet of mains for each consumer in the cases of different utilities.

Most cities show some growth. In certain cases this has been positive, permanent and rapid, in others it has been very slow, even to a negative growth or reduction. Rapidity of community growth affects the depreciation accruing to the utility through obsolescence and inadequacy, causing replacements and enlargements before existing facilities have become worn out.

One of the very important differences between the rates of various water utilities is in the manner in which the total expense has been divided between the public and the private service. By the public service is meant that included in the hydrant rentals. By private service is meant all the remainder, which is sometimes designated as the general service and subdivided into classes termed domestic, commercial and industrial service.

Until a very few years ago the determination of hydrant rentals seems to have rarely, if ever, been put upon a scientific and equitable basis. Such charges were generally, if not always, fixed by a process of bargaining between municipal authorities and the owners or managers of the utilities. The latter naturally got what they could of their total revenues in the form of hydrant rentals and endeavored to spread the balance of the total expense of operation and fixed charges over the general service.

There is probably no need of reproducing here any of the abundant

published data showing how greatly the hydrant rentals have varied in different cities. That such great differences exist seems to be quite widely known. Obviously, if a water works is to have a fair and proper gross income, it must make up from the private consumers, or water takers, whatever amount of fair revenue it fails to get in return for its municipal hydrant service. Rates for the former are clearly dependent in part upon whether or not the latter service yields its just proportion of the total expense.

These and numerous other considerations which might be mentioned, all demonstrate quite clearly that every water plant at least, if not every public utility, has its own peculiarities and individuality. The best interests of both the utility and the public it serves, demand that it be considered separately and independently of all others, except perhaps when all the differences in local conditions are fully understood and due allowances are made therefor. The law of averages has its uses but it certainly is not applicable in determining reasonable rates for one plant by those of others.

In making comparisons between various water plants, for example, it is to be remembered that the statistics of each plant are continually changing and in some cases much more rapidly than others. At any given time the business of each plant in any list that may be taken is in a particular stage of its development and that of each plant is likely to be quite different from all the others. In the writer's judgment these considerations all demonstrate quite clearly that each plant is to be considered upon its own particular conditions and merits as a special case having decided individuality.